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MECHANICAL

GRINDER

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SUMMARY REPORT

ON

TASK ORDER NO. UU

December 31, 1960

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INTRODUCTION

On February 8, 1960, an effort was undertaken under Work Order No. VI, Task Order No. KK, to study methods of utilizing domestic-garbage-disposer equipment or techniques to destroy classified paper in an office area without the operation being noticed outside the office. During that program, many companies manufacturing disposers were contacted, selected commercial disposers were evaluated with water and air as flushing media, and a few simple modifications were tried on one commercial disposer. As a result, it was found that several conventional domestic garbage disposers were capable of satisfactorily pulverizing paper, with a minimum amount of flush water used. With certain cursory modifications, one disposer, the Waste King Model IMP-1, was found to pulverize paper particularly well without the use of water; a constant flow of air provided by the revolving turntable "flushed" the pulverized paper from the disposer.

Although the results of the above-mentioned program established the feasibility of grinding paper, wet or dry, with domestic garbage disposers, certain limitations to the operation remained; also, the use of water was found to be messy and troublesome. Furthermore, consideration of these problems failed to indicate any satisfactory method of solution, and the decision was made not to perform any further research involving water as the flushing medium. The use of air with the slightly modified unit was found to lead to a noisy operation and the motor overheated quickly. In addition, while the particle size achieved in the pulverized paper was quite small, a few legible characters remained. Because comparatively little development effort was possible under Work Order No. VI, and because several promising approaches were envisioned that might solve the problems associated with the use of air, the Sponsor decided that additional research should be considered, directed toward the development of a prototype disposer using air as the flushing medium. Subsequently, on August 1, 1960, Task Order No. UU was initiated, to provide for the performance of such a program.

The requirements of an ideal disposer using air were called out by the Sponsor and are as follows:

(1) It would be small and compact enough to be carried by one man, and would be pouchable.

(2) It would be highly reliable.

(3) It would handle crumpled and/or torn paper in quantities of 4 to 7 bags (25-pound-bag size) per working day maximum. (Normally, it would probably be called upon to handle the contents of 1 to 3 bags per working day.)

(4) It would be operable in a small office.

(5) It would not be aesthetically unattractive in appearance.

(6) It would have a loading hopper so as not to require continuous hand feeding.

(7) It would operate on 110-volt, 50- or 60-cycle current.

(8) Its operation would not attract the attention of people outside the office.

(9) It would pulverize paper completely, so that no legible characters would remain.

(10) It would require little or no instrumentation.

(11) It would provide for easy inspection of its interior after use.

(12) It would produce waste which could be readily disposed of.

After completion of the first laboratory model, a meeting with the Sponsor resulted in a slight change in the first requirement. It was indicated that the portability and pouchability requirement could be relaxed to some extent, to provide latitude for attempting to achieve a further decrease in the operating-noise level of the laboratory model.

This report summarizes the effort performed under Task Order No. UU, during the period August 1 through December 31, 1960.

GENERAL SUMMARY

A previous program had shown that a domestic garbage disposer could be modified to permit destroying paper using air as the flushing medium if certain problems were solved. During the early efforts under Task Order No. UU, satisfactory methods were developed for preventing overheating of the motor, for providing satisfactory feeding of the paper, and for obtaining consistent, acceptable particle size in the dry pulp, i.e., small particles with no legible characters remaining. However, after considerable effort, it was decided that a low operating-noise level could not be achieved in a unit which was pouchable and which could be easily carried by one man. At that stage in the development, a laboratory model was prepared to demonstrate the major features of a possible prototype unit.

During a discussion of the laboratory model with the Sponsor, it was decided that most of the features of that unit were satisfactory, but that the operating-noise level was slightly higher than was considered generally acceptable. Although it was estimated that an adequate reduction of the operating-noise level would result in the unit being larger and heavier, the Sponsor indicated that the disadvantages of increased size and weight would be tolerated in a unit which had a lower operating-noise level. Thus, our efforts were directed toward developing a more quiet unit, within the limits of the contract time and funds.

Subsequently, several experiments were conducted with different materials and configurations to explore practical means of achieving reduction of the operating noise in a unit of this type. Based on the information obtained, an experimental mechanical paper grinder was designed, fabricated, and evaluated. This experimental unit weighed approximately 136 pounds, and was 20 inches square at the top and midsection, 24 inches square at the bottom, and 30 inches high. The unit was coated with a gray painted finish, similar to that commonly found on office equipment, and the casters provided permitted the unit to be readily moved about on the floor. With this grinder, a batch of paper that consisted of about six 8-1/2 x 11-inch sheets was destroyed in about 3 minutes. After approximately 3 batches, the disposable paper bag for collecting the dry pulp had to be removed and a new collection bag attached to the unit.

This experimental mechanical paper grinder appeared to satisfy all but one of the 12 original requirements; the one requirement was not fulfilled because the unit was not small and compact enough to be portable by one man. However, the experimental mechanical grinder did satisfy all of the requirements as revised by the Sponsor.

ENGINEERING ACTIVITY

The engineering activity performed under Task Order No. UU is described in two sections. The first section presents a description of the work through the fabrication and evaluation of the laboratory model. The second section describes the detailed work on operating-noise reduction, and the design and fabrication of the experimental mechanical paper grinder.

Laboratory Model

The effort was initially directed toward the solution of the specific problems associated with the use of air as the flushing medium; these problems included overheating of the motor, inability to achieve a consistently small particle size with no legible characters remaining, lack of good methods of feeding the paper and of collecting the ground material, and excessive operating noise. After these problems were resolved, the design, fabrication, and evaluation of the laboratory model were performed.

Motor Selection

In normal operation, a domestic garbage disposer is flushed with cold water while the garbage is being ground; the water serves to cool the grinding chamber and the disposer frame, as well as to flush away the ground garbage particles. However, the pulverizing of dry paper in a garbage disposer requires considerably more energy than the grinding of wet garbage. It was to be expected, therefore, that the disposer motor would overheat when the disposer was used to grind paper with air as the flushing medium; and this was found to be so.

The disposer selected for modification was the Waste King IMP-1. The 1/3-hp motor in this unit usually overheated within about 1 minute when dry paper was pulverized. It was realized that considerably more power was needed from the motor for paper pulverization, but also that low weight was of importance. With these factors in mind, a replacement motor was selected. This was a 3/4-hp, 60-cycle motor produced by the Dayton Electric Company, Dayton, Ohio; it was approximately the same in size and weight as the original disposer motor.

Tests with the more powerful motor showed satisfactory performance. Although torn paper could occasionally stall the motor, overheating of the motor during the normal grinding process did not occur. As a result of this work, the decision was made to use this 3/4-hp motor in the laboratory model.

Loading Study

During the experiments conducted under Work Order No. VI, Task Order No. KK, it appeared that it might be difficult to evolve a simple feeding process for use with air as the flushing medium. Under such flushing conditions, not only did the paper tend to bounce around above the grinding chamber without much, if any, grinding occurring, but also the condition of the paper being fed appeared to have a significant effect on the extent to which satisfactory grinding was achieved.

Fortunately, a simple feeding configuration was developed early in the program. When a cylindrical tube was placed above the circular-cross-sectioned grinding chamber, paper loaded into the tube could be readily forced down to the grinding mechanism by a cylindrical plug which fitted snugly in the tube and was acted upon by gravity. Although the plug had to be sealed against the tube wall by using a material such as felt, the combination of properly selected seal force and plug weight resulted in satisfactory feeding of the paper to the grinding mechanism, whether the paper was torn or crumpled. The only problem encountered with this feeding method was that occasionally a group of torn sheets which had not separated jammed the grinding mechanism. However, since this aspect of loading could be controlled by the operator, this general feeding method was selected for application.

Particle-Size Study

The results of the previous program revealed that the Waste King IMP-1 gave a promising performance with regard to the degree of destruction. When the rate of feeding was controlled, only a few legible characters remained after a batch of paper had been destroyed.

Under Task Order No. UU, the grinding chamber of the commercial disposer was examined closely. It was found that there were spaces between the grinding chamber and the lower chamber through which relatively large pieces of paper could pass unground. A steel gasket was subsequently inserted between the grinder stator and the housing, so that the size of these passages was reduced. Although this change increased the resistance to air flow between the two chambers, the resultant dry pulp contained no legible characters. It was, therefore, decided that this arrangement would be used in the laboratory model.

To provide an increase in air pressure in order to maintain satisfactory air flow for flushing, metal vanes were added to the bottom of the rotating grinder plate. These vanes acted as scrapers as well as a centrifugal blower in effecting a positive discharge of the dry pulp into the discharge tube.

Dry-Pulp-Collection Study

It was known from the previous program that the achievement of satisfactory collection of the dry pulp would entail some consideration because an air flow that was low enough to permit suitable grinding would not apply much discharging force to the ground material. The dry pulp tended to clog discharge pipes as large as 2 inches in diameter.

Under Task Order No. UU, this proved to be a fairly difficult problem for which to develop a neat and convenient solution. Two methods of dry-pulp collection were tested. One involved the use of a disposable paper bag, and the other, a reuseable cloth bag; in both cases, the bag had to be placed outside the grinding unit housing, so as to facilitate attachment and also removal preparatory to emptying and/or disposal.

In the tests performed, the discharge tube connecting the bag to the lower chamber clogged quite frequently. Ultimately, with the diameter of the tube increased to 3 inches and the length decreased to about 2 inches, the arrangement was found to be reasonably practical and to work adequately. However, as will be noted later, this configuration was changed considerably in the experimental model.

Sound-Attenuation Exploration

The previous program had shown that paper grinding was noisy particularly when air was used as the flushing medium. Under Task Order No. UU, the grinding action of the domestic disposer was examined closely and the related parts were studied in an attempt to find methods of reducing the amount of sound that was generated. Parts of the mechanism were even duplicated on bench models and run, but no method was evolved for significantly reducing the amount of noise originating in the grinding process, without increasing the mass of the unit considerably.

When it appeared that the housing had to provide some sound attenuation for the mechanism, sound measurements were made. These showed that the grinding mechanism produced sound at a level of about 96 decibels at 18 inches; the frequency spectrum ranged generally from 200 to 600 cycles per second, with a peak at about 400 cycles per second. Since this was a relatively high sound level, it was obvious that, even if dampening and vibration-isolation techniques were used, considerable mass would have to be incorporated in the housing as a transmission barrier, in order to decrease the operating-noise level of the unit significantly.

In view of the Sponsor's emphasis on the requirement of low weight, it was decided that the laboratory model would be built with an over-all weight which could be carried by one person, and that to minimize the cost of the laboratory model, some of the known refinements leading to sound attenuation would not be used. However, it was planned that the housing would be prepared so as to make reasonably effective use of the mass of the construction materials. It was expected that evaluation of such a unit would show whether major attention should be given to further sound attenuation.

Model Design and Fabrication

Figure 1 shows the completed laboratory model of the mechanical paper grinder.

The feeding tube and grinding mechanism were enclosed in a sound-attenuation housing fabricated from 3/4-inch-thick plywood. The grinding mechanism was mounted on isolation pads inside this plywood housing. The motor was suspended beneath the housing, and the dry-pulp collector bag was attached to the discharge tube projecting from the lower chamber through the plywood housing. The legs were made of aluminum rod. This unit weighed 57 pounds and measured 14 inches square (at the plywood housing) by 29-1/2 inches high. Additional details of this laboratory model are described in the following.

Motor. The 3/4-hp motor was suspended beneath the plywood housing and attached to the rotating grinder plate through a rubber coupling.

Figure 1. Laboratory Model of Mechanical Paper Grinder

This coupling minimized the effects of misalignment between the motor and the grinding mechanism, and isolated the exposed motor from the noise-generating grinding mechanism.

Loading Hopper. The upper housing of the grinding chamber was machined to provide a recessed opening for the loading tube. A 6-inch-OD, 8-inch-long rigid plastic tube was fitted into the machined recess. The tube dimensions were selected so as to provide the proper rate of paper feed into the grinding chamber.

To assure continuous feeding of paper from the tube into the grinding chamber, a wooden plug approximately 1-1/2 inches thick and slightly smaller in diameter than the ID of the tube was provided; this rested on top of the paper previously loaded into the tube and, under the force of gravity, pushed the paper into the grinding chamber. This plug also reduced the transmission of sound from the grinding chamber out through the loading-tube opening.

To prevent this plug from rapidly becoming worn by the rotating grinder-table vane (discussed below), a metal wear ring was attached to the bottom of the plug. Also, fitted to the periphery of the plug was an overlapping felt gasket, to prevent dry-pulp dust from bypassing the plug. A metal handle was attached to the plug, to facilitate removal from the loading tube. Figure 1 also shows the lid which was used to cover the open end of the loading tube, so that the amount of noise and dry-pulp dust transmitted into the room from the tube could be kept to a minimum.

Grinding Chamber. At first, the only changes in the grinding chamber involved the addition of the steel gasket and the metal vanes as

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described previously. However, tests subsequently performed with the laboratory model showed that it did not always completely destroy the paper. There was a tendency for some of the paper to stay at the center of the rotating grinder table, where it was not ground. This problem was corrected by the addition of a short metal vane to the top of the grinder table, to provide a sweeping motion which continually threw the paper against the shredder ring, where it was ground.

Also during the testing, it was found that, after a period of grinding, dry-pulp dust infiltrated the clearance between the centrifugal-hammer shafts and the hammer-shaft bushings. This effectively reduced the operating clearance of the hammers and prevented them from actively hammering the paper particles against the shredder ring. To correct this condition, flats were ground on the sides of the hammer shafts, and thus a clearance was provided that was sufficient to permit the dry-pulp dust to pass the hammer shafts and shaft bushings. This method of clearing the shaft bushings proved adequate.

Model Evaluation

The laboratory model was used to grind telephone-book pages, carbon paper, regular-weight Bond paper, blotting paper, and IBM cards. Although the operating unit was quite noisy, the particle size of the ground paper was consistently small and no legible characters remained. Crumpled paper was ground quite satisfactorily. Torn paper was readily destroyed most of the time, but occasionally the grinding mechanism jammed. Small pieces of legible paper occasionally remained in the grinding chamber after the operation was concluded; however, these were eliminated by grinding two or three sheets of clean paper before leaving the machine. (It is recommended that any operating procedure ultimately formulated for a unit of this type should include a "final" step which would involve grinding a few clean sheets of paper.)

At this stage of the development, it appeared that all of the previously listed requirements for a satisfactory unit could be met, except for low operating-noise level (Requirement No. 8).

On October 11, 1960, the laboratory model was demonstrated to the Sponsor, and the various features of the unit were discussed in detail. It was concluded that all of the basic aspects of the model were acceptable, and that a few additional features should be considered. These included minor modification of the lid, improvement of the dry-pulp-collection system involving reusable paper or cloth bags, housing of the entire unit in sheet metal rather than plywood, provision of handles and casters, painting of the entire unit a light-gray color, and a few others. Also, there was mutual concurrence that additional attempts should be made to reduce the weight.

Subsequently, the above-outlined features were generally incorporated in the unit, and on November 2, 1960, the modified unit was demonstrated to the Sponsor and an associate. In general, the unit was deemed to be quite satisfactory; however, on re-considering the operating-noise level, the Sponsor decided that this was probably high enough to merit further investigation of the operating-noise problem.

Based on the cursory operating-sound measurements which had been made in relation to the laboratory model, we estimated that a major decrease in sound level could be achieved only by a significant amount of sound testing, redesign, and fabrication. In addition, it was estimated that a mechanical paper grinder which was modified so as to operate more quietly would be significantly larger and weigh at least 100 pounds. In view of these two estimates, the Sponsor decided that the weight and size requirement could be relaxed, in order to permit achieving a lower operating-noise level; and agreed that the unit resulting from this effort would be considered to be an experimental model rather than a prototype grinder.

Experimental Model of the Mechanical Paper Grinder

Although many features of the experimental model had been established, it was apparent that the decision to achieve a more quiet unit would result in several changes. For example, in order to obtain better sound isolation, it was deemed necessary to use a different method of mounting the grinding mechanism, and this was more complicated than the previously used method. Also, the housing had to be made larger, heavier, and, of necessity, more complicated. Further, the larger housing complexed the dry-pulp discharge and collection system because of the ever-present need for a short discharge tube.

A description of the effort performed on sound attenuation, experimental-model design and fabrication, and experimental-model evaluation is presented in the following.

Sound-Attenuation Study

As described previously, no method had been evolved for reducing the amount of sound actually generated by the grinding mechanism.

Consequently, it appeared that increased sound attenuation had to be obtained by means of a more effective housing.

Sound attenuation may be achieved by one or more of four basic means, namely, the use of a high-mass material as a sound-transmission barrier; the use of sound-absorbent materials such as Fiberglas and acoustical tile; the use of sound-deadening materials, such as mastics and paints, to minimize the vibration of any panel-type components; and the isolation of noise producers from potential noise amplifiers.

A further study of the nature of the sound generated and of the general configuration of the grinding mechanism indicated that a significant reduction in operating sound could be expected from implementation of all of the above-indicated basic methods except the reduction of panel vibration; the vibration did not seem to be a major source of the noise.

Before an improved housing design was started, it was decided that some preliminary experiments should be conducted to obtain an "order of magnitude" feel for the beneficial effects of the three methods of sound attenuation. After this investigation was concluded, the effort was directed toward adaptation of selected features to a housing design and the associated performance of sound measurements.

Preliminary Sound Measurements. Figure 2 shows the enclosure configurations used in the preliminary tests, while Table 1 lists the sound measurements for the different enclosure combinations evaluated. As reported previously, the grinding mechanism with no enclosure gave a 96-decibel reading at 18 inches. When the grinding mechanism was placed on isolation mounts within a 3/4-inch-thick plywood box, a reading of 89

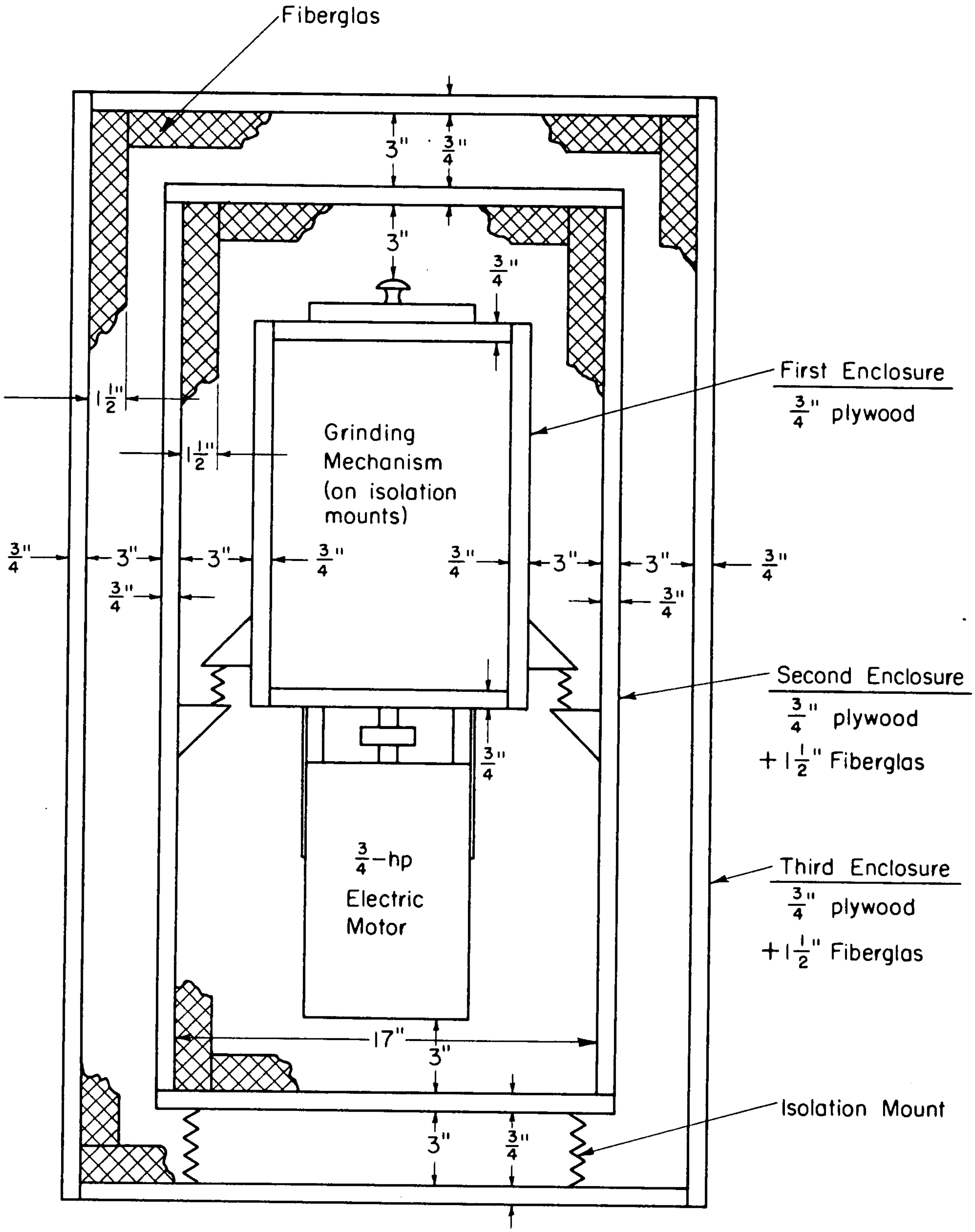

FIGURE 2. SCHEMATIC DRAWING OF ENCLOSURE CONFIGURATIONS USED IN PRELIMINARY SOUND-ATTENUATION EXPERIMENTS

TABLE 1. RESULTS OF PRELIMINARY SOUND-ATTENUATION EXPERIMENTS

Condition	Reading at 18 Inches, db
No enclosure	96
First enclosure (no openings)	89
First + second enclosures (no openings)	80
First + second + third enclosures (no openings)	59
Ambient	50

decibels was obtained. This was essentially the configuration used in the laboratory model.

When the motor and enclosed grinding mechanism combination was placed on isolation mounts and surrounded by a second 3/4-inch-thick plywood box lined with 1-1/2-inch-thick Fiberglas absorbent material, a reading of 80 decibels was obtained. This level is comparable to that generally associated with offices using billing machines, adding machines, typewriters, or similar equipment. The addition of a third lined enclosure and isolation mounts reduced the noise level to 59 decibels. This was considered comparable to the operating sound of a quiet furnace blower.

From this work, it was concluded that a sound level of 65 to 70 decibels could be attained around the grinding mechanism if three enclosures were used. The need for motor cooling, collector-bag accessibility, etc., militated against the use of more than one enclosure around the portion of the unit below the grinding chamber. However, it appeared that the use of three enclosures around the grinding mechanism and one enclosure around the motor portion would result in an over-all operating-sound level of about 75 decibels. This level was considered to be acceptable.

To assist in our sound-attenuation efforts, the Sponsor arranged for Mr. Hale Sabine of the Armour Research Foundation to meet with us. During the meeting, Mr. Sabine confirmed our conclusions and our thoughts regarding factors such as enclosure configuration, material spacing, and isolation methods. Further, it was agreed that it would be better to use sheet metal rather than plywood as the transmission-barrier material; sheet metal is generally a better transmission barrier due to its high mass/flexibility ratio.

Design Experiments. After the preliminary sound measurements and discussions, there followed a significant period of design and sound-measuring effort. Different configurations for selected parts were envisioned in an attempt to combine various practical features with sound-attenuation measures, and sample set ups were prepared and evaluated. The effects of material thicknesses, distances between parts, different isolation mounts, and other factors were investigated. Finally, the housing configuration shown in Figure 3 was selected as representing a good combination from the stand-points of sound attenuation, weight, structural strength, maintenance, and ease of operation.

This arrangement provided for three enclosures around the grinding mechanism, and thus provided for sound absorption and barriers to sound transmission; one enclosure was used around the motor portion. Vibration isolators were placed at important locations. The ground-paper discharge was arranged to take place downward instead of to the outside. In this way, the length of the discharge tube was kept to a minimum and the collector bag was surrounded by only one enclosure.

Model Design and Fabrication

Figures 4 through 7 show the actual configuration of the various components, including the sound-attenuation parts, as designed and fabricated for the experimental mechanical paper grinder.

Figures 4 and 5 display the grinding mechanism and motor mounted to a 1/4-inch-thick aluminum plate 12 inches square. The mounting plate was fastened through isolation mounts to the top of a base, prepared from

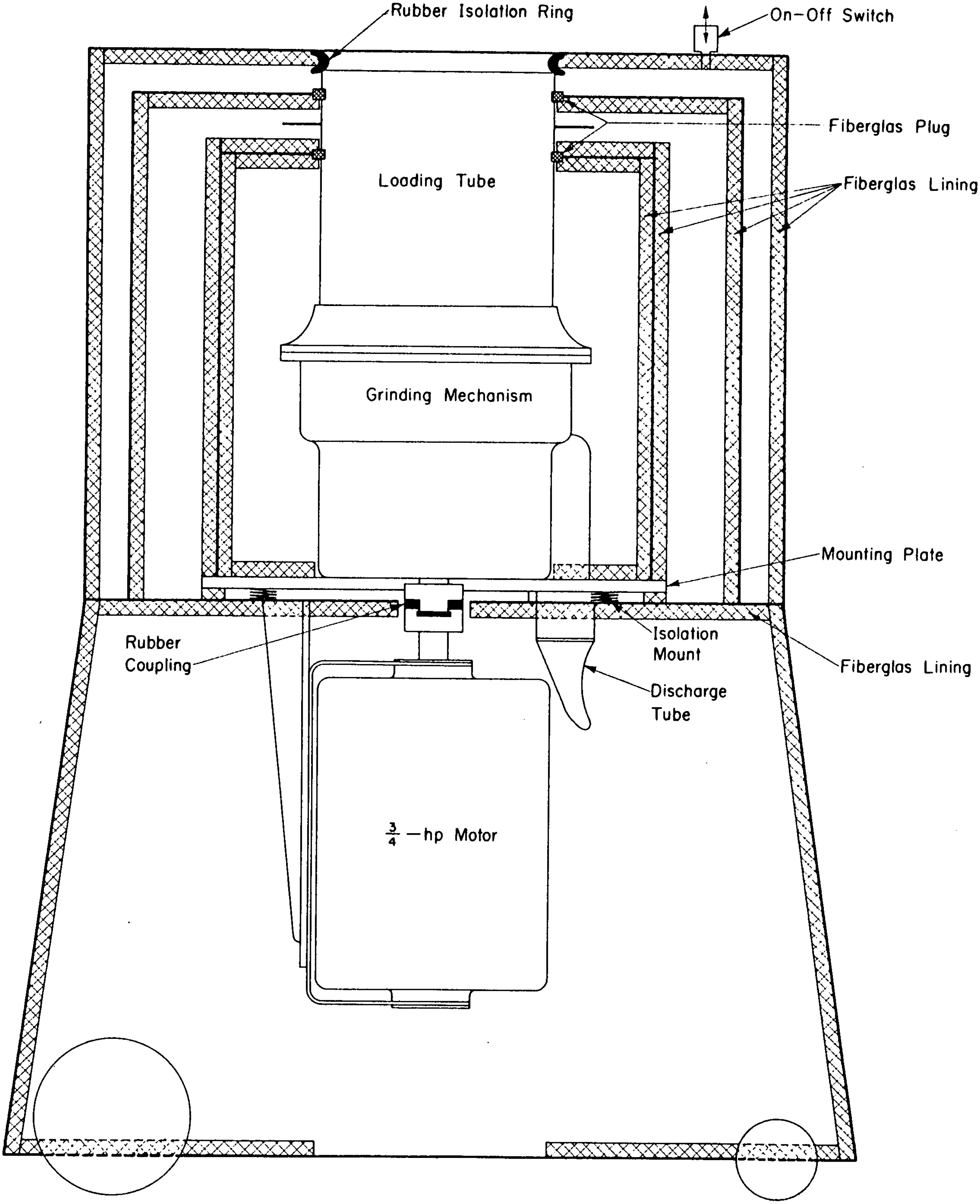

FIGURE 3. HOUSING CONFIGURATION BASED ON DETAILED DESIGN AND SOUND-MEASUREMENT EFFORT

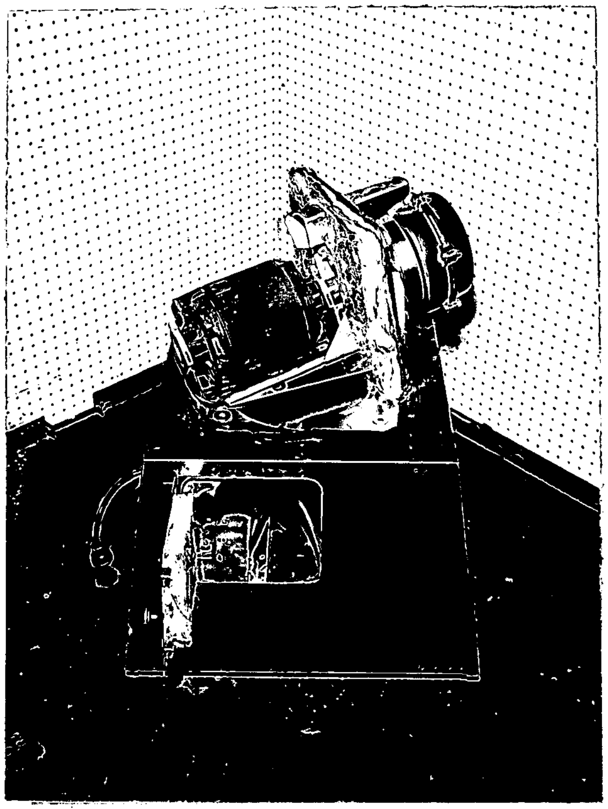

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Figure 4. Grinding Mechanism and Motor Attached to Aluminum Mounting Plate

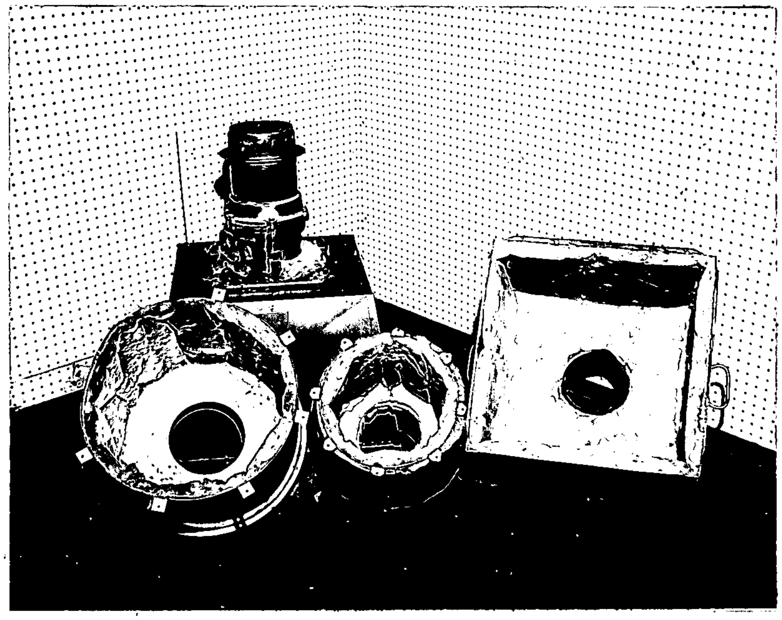

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Figure 5. Three Enclosures for Grinding Mechanism

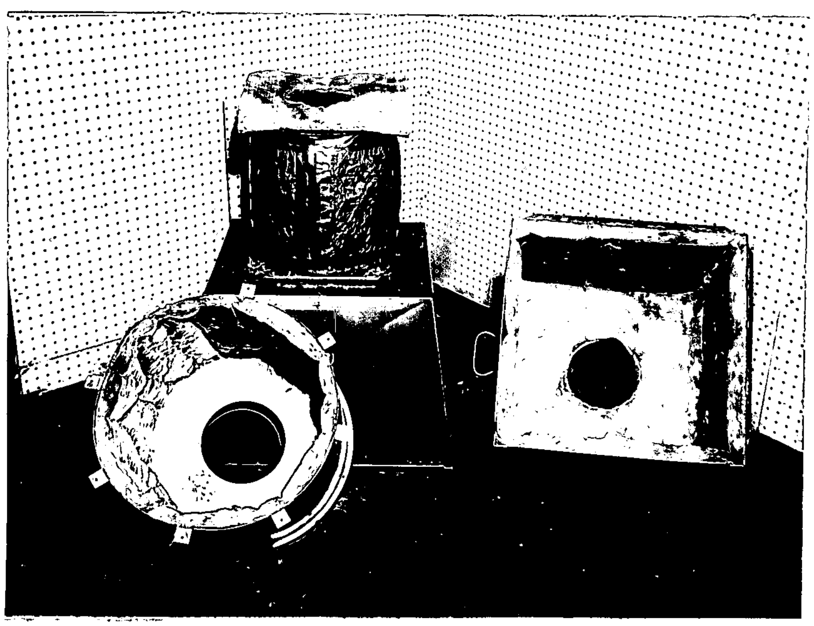

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Figure 6. Inner Enclosure in Place

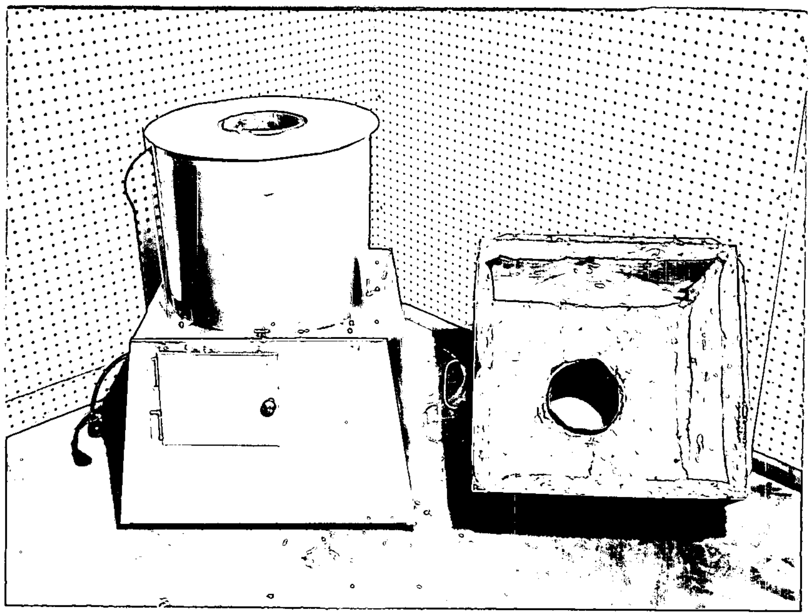

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Figure 7. Middle Enclosure in Place

18-gage sheet metal and measuring 20 inches square at the top and 24 inches square at the bottom. The mounting plate and the base were lined with 1-1/2-inch-thick Fiberglas (also, Figure 3). Also illustrated in Figure 5 are the three enclosures for the grinding mechanism.

Figure 6 shows the inner enclosure assembled in position around the grinding mechanism and attached to the mounting plate. The enclosure was made of 16-gage steel tubing, 11 inches in diameter, and was lined inside and out with Fiberglas. A slight clearance was provided between this enclosure and the feeding tube, and this was plugged with Fiberglas (Figure 3). The top of this enclosure was located about 4 inches below the top of the tube.

Figure 7 presents the middle enclosure in place and the outer enclosure ready to be attached. The middle enclosure was made of 26-gage steel, 16 inches in diameter, with an inside lining of Fiberglas. It was fastened directly to the top of the base; a clearance was provided at the loading tube and this was plugged with Fiberglas (Figure 3). The outer enclosure was 20 inches square in cross section and was made of 18-gage steel with an inner lining of Fiberglas; one end was fastened to the top of the base, and the other end, to the loading tube through a rubber isolation ring.

At a location between the inner and middle enclosures, a thin, metal disk was fitted snugly around the loading tube (Figure 3). This was provided to serve as a physical barrier to sound transmission.

Other features of the experimental model are shown in Figures 8 through 11. A wooden lid provided access to the "floating" plug and to the loading tube. A metal door located on the side of the base led to the collection bag, the motor, and an electrical extension cord, which extended to the outside. Two handles located on opposite sides of the housing

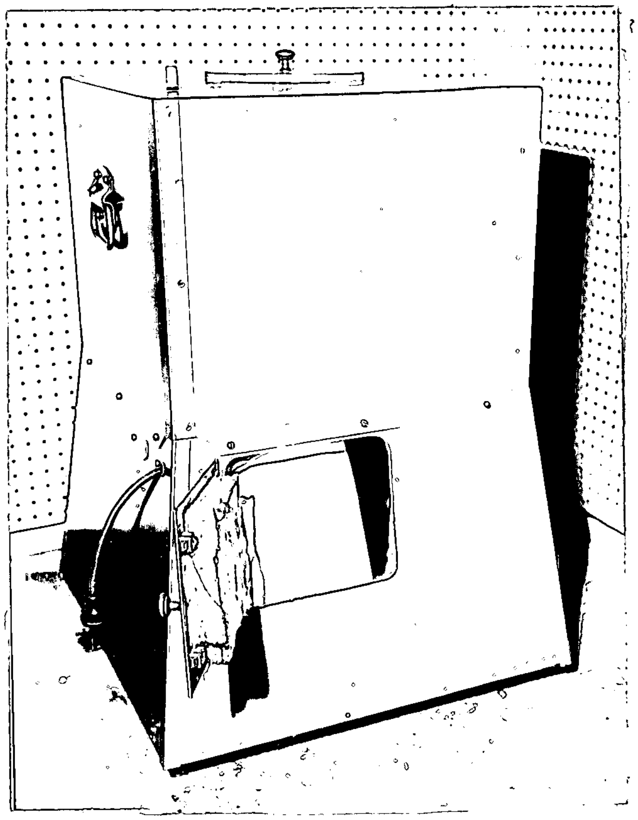

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Figure 8. Assembled Experimental Model Showing Access Door Open to Collection Bag and Motor

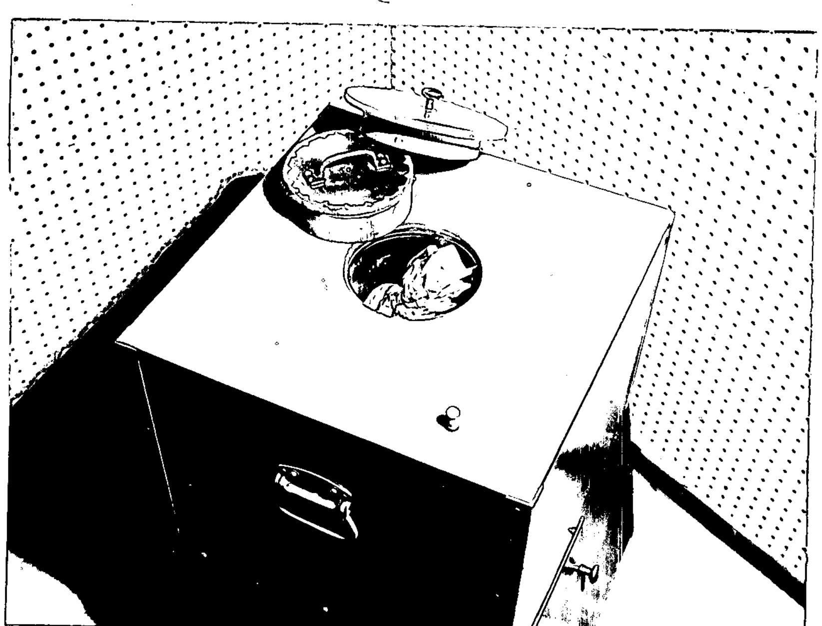

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Figure 9. Assembled Experimental Model With Plug and Lid Removed to Show Crumpled Paper in Loading Tube

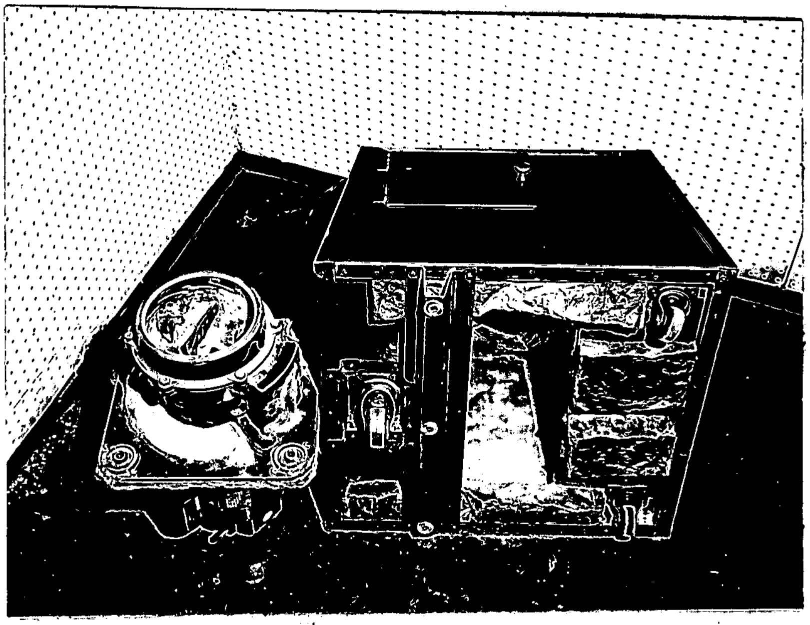

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Figure 10. Grinding Chamber and Bottom of Experimental Model

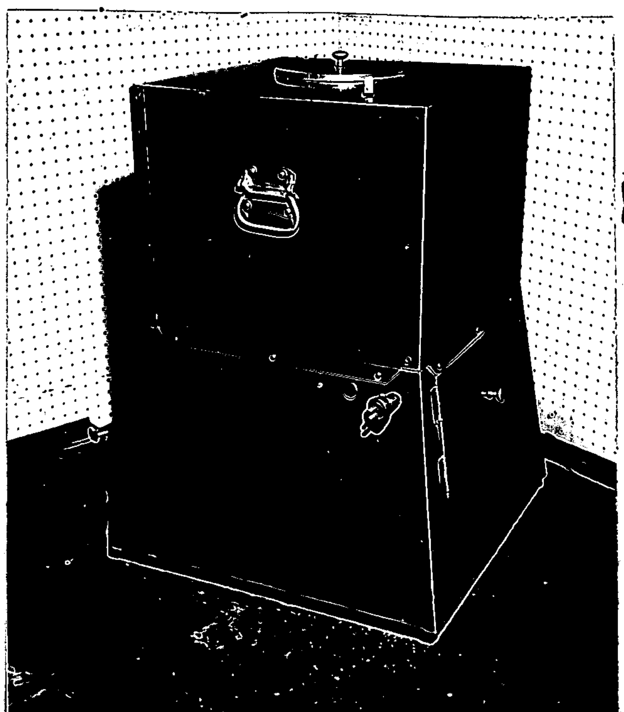

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Figure 11. Assembled Experimental Model of Mechanical Paper Grinder

permitted the unit to be moved easily along the floor on three casters or facilitated lifting the unit; the casters provided a firm foundation even when the floor was not completely level.

A disposable paper bag about 14 inches long and 4 x 6 inches at the opening was selected for use with the experimental unit. Its capacity was sufficient to handle the dry pulp obtained from three average-sized loading-tube batches. These bags are commercially available for Hamilton Beech sweepers and are designated L-26. A rectangular spring-steel frame was prepared so that the paper collection bag could be easily attached to the discharge tube. When a bag was to be attached, the frame was compressed, slipped into the bag opening, and then released so as to maintain the proper bag opening and to help support the bag in the proper position. An elastic band, attached to a cloth transition piece, which in turn was fastened to the spring-steel frame, was then easily slipped into position over the irregularly shaped end of the discharge tube.

A few other features of the laboratory model were changed for the experimental model. The discharge tube was made larger and brought out the bottom of the experimental model; this change practically eliminated clogging. Also, the motor was replaced with a General Electric 3/4-hp motor rated on 50- or 60-cycle current. Although this motor was somewhat larger than the previous motor and was 13 pounds heavier, it did a good job and fitted into the unit. This is identified as a General Electric No. 5 KC 48565 X motor in a No. 56 frame; it operates at 1,425 rpm and has a thermal overload switch. An electrical switch was mounted on the top of the experimental unit, for use in starting the motor.

Two coats of gray paint were applied to the exterior of the unit. The color was selected on the basis of trying to provide a finish which would fit well in an office environment.

As completed, the experimental model of the mechanical paper grinder weighed 136 pounds, and was 30 inches high, 20 inches square at the top and midsection, and 24 inches square at the bottom.

Model Evaluation

Upon completion of the experimental model, tests were run to evaluate its general operation, and various types of paper, as mentioned previously, were ground. The results were good, and no legible characters remained. The unit destroyed about six 8-1/2 x 11-inch sheets of paper in about 3 minutes. The grindings from about 3 batches of paper, 6 sheets per batch, filled the collection bag; this then had to be either emptied or replaced. Under normal load, the 3/4-hp electric motor did not overheat and the mechanism did not stall. However, it was found that packing the paper tightly in the loading tube ultimately resulted in overloading and stalling of the unit.

Minor difficulty was experienced with the chamber not being completely clear after a load of paper was apparently destroyed; in a few instances, a small piece of paper was found wrapped around the grinder-table center vane. This vane was normally vertical in position, and, as the table rotated, the paper tended to hold on the vertical sides of the vane. After the vertical sides were bent about 10 degrees from the vertical plane counter to the direction of table rotation, the paper passed over this vane readily, and the problem was thus corrected.

The operating-noise level of the experimental model was 80 decibels at 18 inches. Although this was considered to be acceptable for most offices, it was felt that the unit might not be quite quiet enough for a few rigorous applications. Further, while it appeared that minor reductions in over-all weight and size could be obtained through more design effort, it was felt extremely unlikely that an experimental unit with this operating-noise level and with a size and weight approaching those, respectively, of the laboratory model could be developed without a major change being made in the grinding mechanism.

Following the completion of the experimental-model evaluation, the unit was demonstrated to the Sponsor on December 28, 1960. Upon agreement that the revised project objectives had been fulfilled, the experimental unit was shipped to the Sponsor (on January 4, 1961).

FUTURE WORK

The Sponsor indicated that the experimental mechanical grinder would be used to determine the response of various possible users to all aspects of the unit. Depending on the results of various demonstrations and also on the estimated production cost (which was to be obtained by the Sponsor), a decision would be made either to fabricate a few units of this kind or to modify this unit before producing a few more. In this connection, we emphasized to the Sponsor that several important components of the unit had not been life tested in any way and that some sort of life-test program should be undertaken on the critical parts before more units were fabricated.

(On March 7, 1961, at the request of the Sponsor, we submitted a proposed program of further research on the mechanical paper grinder. This program was directed toward the life evaluation of selected components of the experimental grinder, and also toward the preparation and evaluation of a prototype unit which would incorporate selected modifications stemming from the life-evaluation efforts as well as from the demonstrations which had previously been performed by the Sponsor.)

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